A Coordinated Framework for Soybean Rust Surveillance, Reporting, Prediction, Management and Outreach

April 14, 2005
(revised May 2005)

In response to the recent introduction of soybean rust (SBR) *Phakospora pachyrhizi*, into the United States, USDA is facilitating the development of a federal/state/industry coordinated framework for surveillance, reporting, prediction, management and outreach for the 2005 growing season. The cooperating USDA agencies include the Cooperative State Research, Education and Extension Service (CSREES), the Agricultural Research Service (ARS), and the Animal and Plant Health Inspection Service (APHIS). The plan was announced at an USDA-APHIS-sponsored meeting with stakeholders from industry, federal, state and universities on February 4, 2005 in Indianapolis, Indiana. The multi-agency group assigned to develop the plan includes: Roger Magarey, Coanne O'Hern, (USDA-APHIS); Rick Bennett, Richard Wilson, Doug Luster, Glen Hartman, Monte Miles (USDA-ARS); Geir Friisoe (National Plant Board), Kitty Cardwell (USDA-CSREES), X.B. Yang (Iowa State University), Bill Dolezal (Pioneer), Scott Isard (Penn State University), Don Hershman (University of Kentucky), David Wright (NCSRP), Bev Paul (American Soybean Association) and Stephen Muench (United Soybean Board). The framework draws from ideas and material presented at the USDA-ARS Strategic Planning meeting held on December 1-2, 2004.

Deliverables

The goal of the framework is to provide stakeholders with effective decision support for managing soybean rust during the 2005 growing season. We intend to achieve this goal through consensus-building and commitment of cooperating parties on our roles and responsibilities, and delivery of our respective contributions (i.e. disease observations, diagnostic results, decision support paradigms, models, etc.), through means that hold all parties accountable, and provide communication with stakeholders. The basic deliverables of the framework are outlined below.

1) Deliver a surveillance and monitoring network to provide timely information of the incidence and severity of soybean rust in the United States, Caribbean basin, and Central America.
2) Provide a web-based system (USDA Soybean Rust Monitoring and Prediction System) for information management of monitoring observations, forecasts, and decision criteria to stakeholders.
3) Develop decision criteria for fungicide application.
4) Provide predictive modeling of aerial transport of SBR spores from active source regions to soybean growing areas in the U.S.
5) Provide outreach for training, education, interpretation of web-based SBR monitoring and prediction displays, and dissemination of information.

APHIS has been identified as the lead agency on soybean rust in 2005, but a separate transition plan for future years involving federal, state and industry contributions is currently under development.

Introduction

Soybean rust was introduced into the continental United States in the fall of 2004, presumably as a consequence of tropical storm activity. Model predictions indicated that soybean rust had been widely dispersed throughout the southeastern United States, and subsequent field and laboratory observations confirmed this distribution. Figures 1 and 2 provide information on spore deposition in late 2004 and overwintering areas for soybean rust in the continental United States.

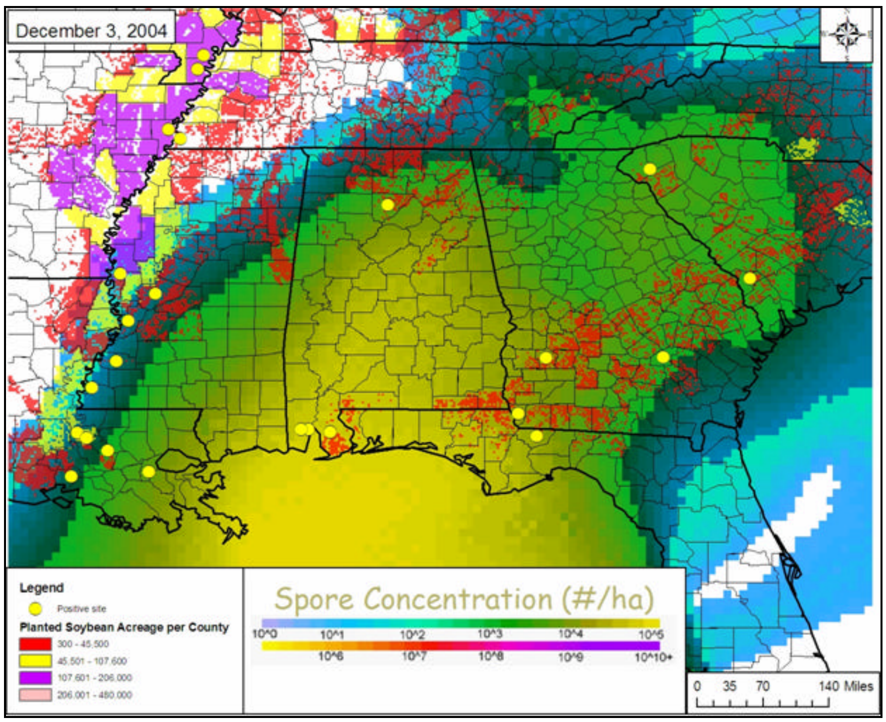

Figure 1. Estimated initial distribution of soybean rust, based on spore deposition and confirmed observations (yellow circles) as of December 3, 2004.

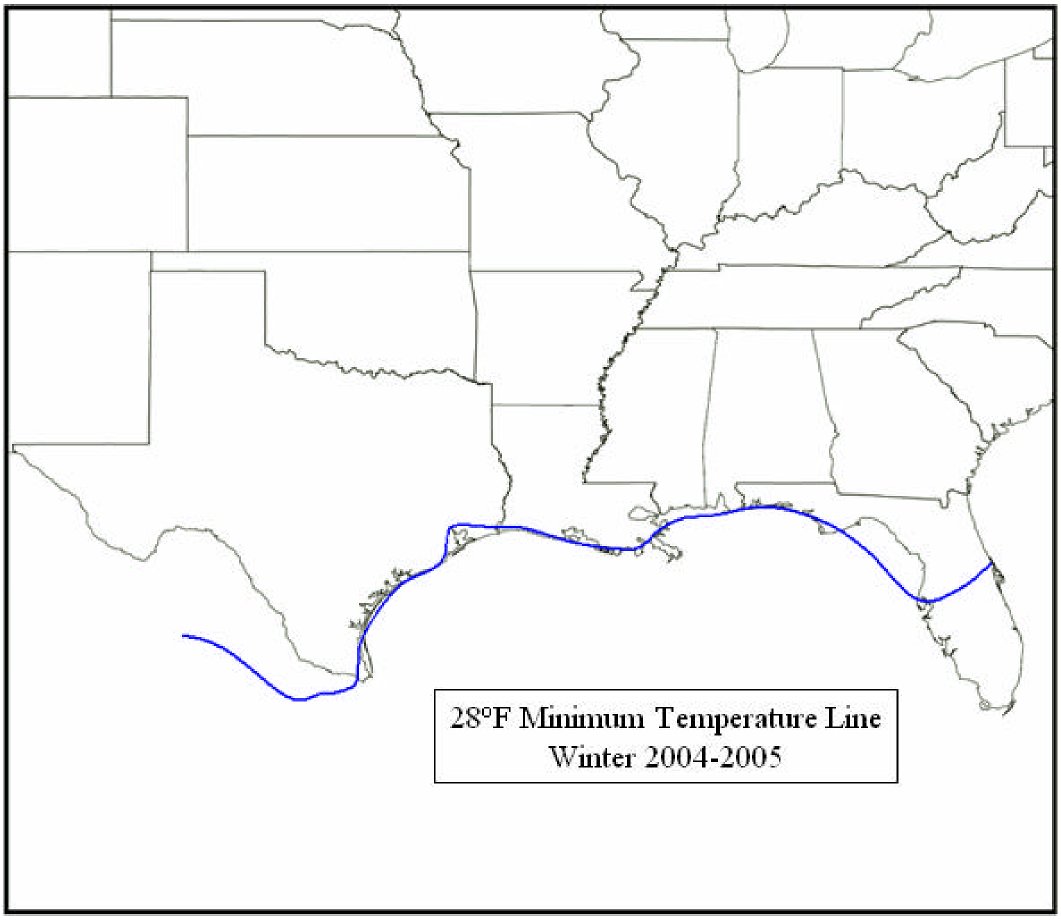

Figure 2. Estimated overwintering area for soybean rust based on the number of accumulated days with the minimum daily temperature less than 28 ºF as of January 28, 2005. Overwintering areas for hosts of soybean rust exist south of the 28ºF isopleth.

A comparison of predicted spore deposition (Figure 1) and overwintering areas (Figure 2) indicates rust survival will be limited, but present in the continental United States as of January, 28 2005. It is important to note that the predicted area of soybean rust deposition included the western Caribbean, south-eastern Mexico and Central America (Figure 3). **Soybean rust has not been confirmed in these regions and the potential for spore production is unknown. If present, the sub-tropical and tropical climates of these regions are likely to ensure year round survival of the pathogen.**

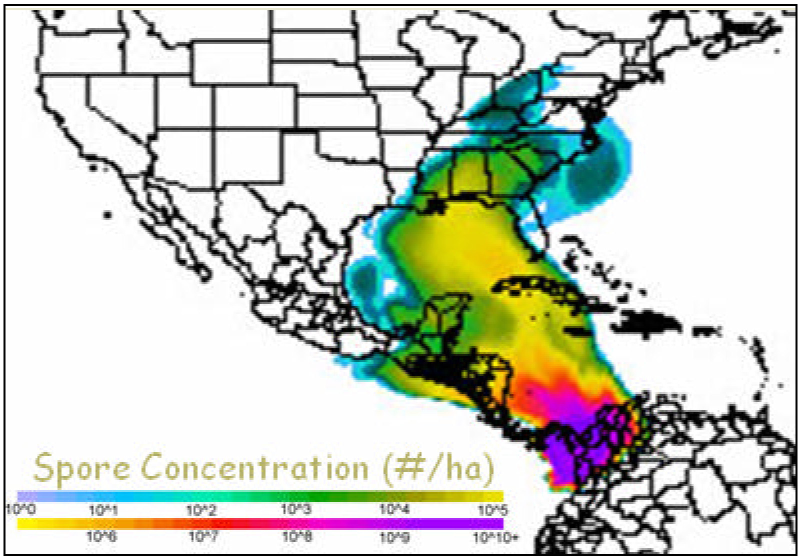

Figure 3. Simulated deposition of soybean rust spores during September 2004 during atmospheric conditions associated with the passage of hurricane Ivan through the Gulf of Mexico. The simulation assumes a source area in northern South America.

Experience with other aerially dispersed pathogens such as tobacco blue mold, confirms the potential of the western Caribbean and Yucatan peninsula to act as overwintering source areas for the initiation of epidemics in the continental United States.

The current USDA efforts to monitor and predict the distribution of soybean rust follows previous APHIS efforts to prevent the introduction and establishment of exotic pests. In 2003, USDA CSREES set-up the National Plant Diagnostic Network (NPDN), which is a network of Land Grant University and State Department of Agriculture plant disease and pest diagnostic clinics from across the United States. The NPDN allows diagnosticians, State Regulatory personnel, and first detectors to efficiently communicate information, images, and methods of detection in a timely manner. The APHIS Cooperative Agricultural Pest Survey (CAPS) program conducts annual surveys for exotic pests with national, regional and state targets. The CAPS program has supported a number of novel techniques and methods for pest survey and detection. Beginning in 2002, APHIS in association with North Carolina State University, sponsored the development of the NCSU APHIS Plant Pest Forecast System (NAPPFAST). The NAPPFAST system uses biological models, climate and other GIS data layers to forecast pest occurrence. As part of this effort beginning in 2003, APHIS began the development of the Integrated

Aerobiological Modeling System (IAMS), which was designed to track the aerial movement of invasive pests and focused on tracking the off-shore movement of soybean rust. Beginning in late 2004, following the first detection of soybean rust in the continental United States, the IAMS system was modified to create a specialized system focused solely on soybean rust – the Soybean Rust Aerobiology Prediction System (SRAPS). These pest forecasting innovations laid the information technology foundation for the USDA framework.

The Soybean Rust Aerobiology Prediction System (SRAPS) will provide information for locating strategic sites to monitor for soybean rust incidence and severity during spring and summer 2005. Climatologically-based assessments of the potential occurrence of *P. pachyrhizi* epidemics using three different soybean rust overwintering scenarios will be produced and provided to stakeholders on the project's website. Components of the analysis include: (i) source area delineation based on soybean crop and kudzu distributions, (ii) three temperature-based overwintering scenarios (warm, average, cool) for the Caribbean basin (including southern U.S.), (iii) Normalized Difference Vegetation Index (NDVI)-calibrated, temperature-driven greening function for North America, (iv) evaluation of spore aerial transport potential using 24 years of data (National Weather Service (NWS) Reanalysis 2 data set) including pressure, wind and temperature data fields with 6 hr resolution and corresponding cloud cover and precipitation records, (v) soybean crop growth model driven by daily temperature and precipitation data from past 5 years, and (vi) soybean rust epidemiology model driven by daily temperature and leaf wetness data from past 5 years. The assessment will describe the level of risk (low, medium, high) of SBR epidemics occurring in U.S. regions and will be delivered by early March 2005 on three maps, one for each overwintering scenario.

The five basic deliverables of the framework cover the important components of a properly coordinated response namely surveillance and monitoring, information dissemination to stakeholders, decision criteria for disease management, disease prediction models, communication and outreach. Each component includes general and specific protocol information and addresses issues of resource and personnel allocation.

1. Domestic and international SBR surveillance and monitoring system

The following describes a framework for a coordinated national monitoring system. The monitoring program will be a cooperative effort between State Departments of Agriculture, Land Grant Universities, industry, the National Plant Diagnostic Network (NPDN) and the USDA. The objective is to build a framework on which individual monitoring efforts can be coordinated. As a part of this effort soybean production states were requested to provide information about their proposed soybean rust monitoring efforts in 2005. Many states are in an advanced state of readiness, while others are seeking guidance and/or funding. A list of participating states including names of key personnel are listed in Appendix A .

This document provides suggested protocols for the monitoring effort including resource allocation, data collection and data communication. It is important to note the suggested distribution of resources is subject to negotiation and also represents a minimum, leaving states free to deploy additional resources at their own discretion.

The monitoring program includes six components:

1) A fixed-site sentinel program to estimate spore production in overwintering and growing season source areas;
2) A mobile survey to confirm new source areas and to calibrate spore deposition from the soybean rust prediction model;
3) Surveys by industry to provide confirmation of rust in additional locations;
4) Passive surveillance system through public and private sample submission to the National Plant Diagnostic Network (NPDN);
5) International monitoring to determine the importance of off-shore SBR source areas.
6) A program involving spore sampling in rain that will provide early warning and assist with model calibration of predicted spore deposition concentrations.

i) Sentinel network

Sentinel plots are being funded by the USDA and the North Central Soybean Research Program (NCSRP). The USDA program covers 31 soybean growing states (also 4 states which have other bean production areas) and the NCSRP program 20 states (Table 1). In some states there maybe a separate leader for NCSRP and USDA sentinel plots, and in other states there may be a single leader for both. One protocol has been developed for both NCSRP and USDA plots and data from both programs will be uploaded to the USDA SBR database for viewing on the SBR public web site.

There are three functions of the sentinel program. One is to quantify the timing of spore production in overwintering and growing season source areas. Spore production in source regions is important input for the soybean rust aerobiology prediction system. The second function serves as a warning network for new disease observations in the soybean production regions. Consequently, those states in the Southern and Mississippi River Valley areas have a higher density of plots relative to their soybean production acreages. The third function provides a means to collect data for epidemiological research. The epidemiological research sentinel plots use the plant based protocol shown below. If possible, these plots should not be destroyed and observations should continue beyond the first detection of SBR. Therefore, it is important that some plots in each state should be epidemiological research sentinel plots.

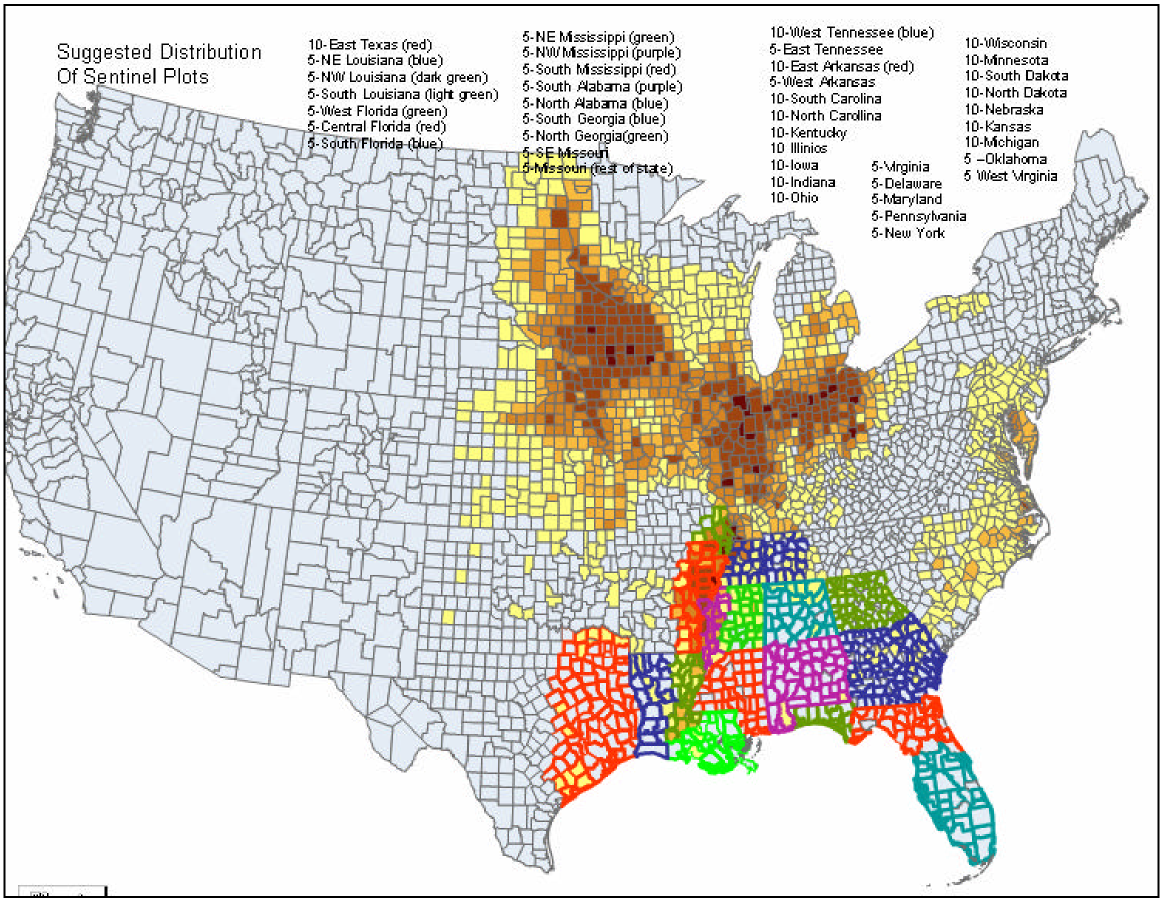

Figure 4. Distribution of USDA sentinel plots and soybean production areas (NASS, 2002)

Table 1. State soybean production, kudzu acreage and proposed sentinel plot information.

State	Soybean Acreage 2004[a]	Average Planting Date[b]	Kudzu Acreage[c]	USDA Sentinels	NCRSP Sentinels[d]
Alabama	190	May 25 to June 25	117510	10	20
Arkansas	3150	May 25 to June 20	10091	15	20
Delaware	208	May 28 to June 26	1	5	
Florida	17	May 15 to June 15	12449	15	20
Georgia	270	May 27 to June 27	151318	10	20
Illinois	9900	May 15 to June 9	529	10	20
Indiana	5520	May 15 to June 5	98	10	20
Iowa	10150	May 14 to June 2		10	20
Kansas	2710	May 25 to June 20	6	10	20
Kentucky	1300	May 25 to June 25	18051	10	20
Louisiana	990	May 15 to June 15	4824	15	20
Maryland	495	May 28 to June 26	134	5	
Michigan	1980	May 18 to June 3		10	20
Minnesota	7050	May 16 to June 3		10	20
Mississippi	1640	April 25 to May 25	250632	15	20
Missouri	4960	May 25 to June 1	1166	10	20
Nebraska	4750	May 18 to June 4	51	10	20
New Jersey	103	June 14 to July 14	9	5	
New York	172	No data		5	
North Carolina	1500	May 20 to June 30	57660	10	
North Dakota	3570	May 19 to May 29		10	20
Ohio	4420	May 10 to June 7	58	10	20
Oklahoma	290	May 18 to June 22	31	5	
Pennsylvania	425	May 20 to June 10	1	5	
Puerto Rico		No data		5	
South Carolina	530	May 27 to June 27	73742	10	
South Dakota	4120	May 20 to June 6		10	20
Tennessee	1180	May 30 to June 25	64862	15	20
Texas	270	May 3 to June 14	50817	10	
Virginia	530	May 20 to June 30	11357	5	
West Virginia	18		1318	5	
Wisconsin	1550	May 15 to June 20		10	20
Total	**73598**	**---------------------------**	**826717**	**300**	400

State	Dry bean Production '000s acres	Average Planting date	Sentinels
Colorado	219		5
Idaho	31		5
Oregon			5
Washington	20		5
Total	**270**		**20**
Grand Total	**73868**		**320**

[a] NASS 2004. [b]NASS, 2002 [c] Data from Daryl Jewett, APHIS. [d] States participating in Proposed North Central Soybean Research Fund project on monitoring (XB Yang and D. Wright, Personal Communication).

Following the recent findings of the first report of soybean rust caused by *Phakopsora pachyrhizi* on dry beans in South Africa (Du Preez, 2005, Plant Disease Notes, APS) there has been an effort to add additional states to the program that have dry bean production. These states include Idaho, Washington, Oregon and Colorado. Additional details on monitoring programs in these states are being collected. (see Table 1 – bottom)

It is anticipated that one person could check 4-6 plots per day, depending upon travel time. Consequently, states with five plots might require 8 to 16 hours per week. States with 10 plots may require 16 to 24 hours per week. It is likely sentinel plots would need to be maintained over a 3 to 4 month period. Where possible sentinel plots should be maintained at an unsprayed site or at a grower site as an unsprayed strip should be left so that observations can continue. Leaving an unsprayed strip has been a practice widely used in Brazil. As well as allowing the monitoring program to continue, the strip often provides a visual reminder of the importance of fungicide application. The cost of the sentinel plot system has been estimated at $2,500 per plot per season. A total of 320 USDA funded plots are recommended across the nation at a total cost of $800,000.

General Information

Surveys areas and/or plots should be:

- **Where practical, existing production areas can be used rather than the expensive and labor intensive custom planting of plots**.
- Concentrated in areas south of the 28° F overwintering line or on legumes that survive winter.
- Sentinels plots may include pigeon pea, yam beans, kudzu and leguminous winter cover crops.
- Strategically placed near large reservoirs of overwintering inoculum that may be proximal to production areas
- Sentinel plots should be observed at least once per week. When model predictions or observations indicate rust appearance is imminent then observations should be every three days. Once rust has been detected in the plot, observations should be weekly.
- Early maturing varieties of soybean are the most preferred host for sentinel plots.
- A certain proportion of plots will be designated 'epidemiological' plots. The protocol for these plots will dictate more intensive disease observations than in the regular sentinel plots. The data from the epidemiological plots will also be used to drive the decision support system for farmers.
- The first positive or suspected positive in each sentinel plot should be confirmed by the diagnostic lab or USDA certified expert. New state confirmations should be confirmed by sending samples to the APHIS-PPQ National Identification Services, but only through the State and/or Land Grant University (NPDN) lab as a first screen (see Federal/State Responsibility for Identification of *Phakopsora pachyrhizi*, USDA-APHIS-PPQ, December 6, 2004; revised May 2, 2005. (Appendix B or http://www.aphis.usda.gov/ppq/ep/soybean_rust/sbridv4.pdf).

For sentinel plots using soybean as the host:

- Plots should be approximately 2500 sq. feet (50 x 50 ft). Scout the central 30 x 30 ft area. Assess three different sites (stops) in each plot. The sites should be in a v-shape not a straight line.
- Use highly susceptible varieties
  - Maturity: mixture of early and late maturity
  - Mixed planting: 4-row per variety with no spacing between varieties.
- For frost control in northern areas on early planted varieties, it is recommended to plant twice if the plot is not covered with sheeting. Use insecticides for control of bean leaf beetle where appropriate.
- For a normal sentinel plot, a row-based evaluation should be made with disease severity observations made in the crop at three heights (low, middle and high).
- Another option is to collect a more intensive data set that can be used for epidemiological research. The research protocol assesses rust severity at three sites per plot and five plants per site. Disease severity is rated on each node beginning on the lowest attached leaf and ending with the first fully expanded leaf. Supporting plot data needs only to be entered once by the scout. Information needed is: GPS location, cultivar description/name, planting date, row spacing, planting density and field acreage.
- During each observation record the date, plant height, degree of canopy closure, and the vegetative and reproductive growth stages.
- Disease severity should be assessed using the following categories. Absent, low, medium, high. A key to disease severity in located on the SBR restricted site.

For sentinel plots using non-soybean hosts:

- Plots should be approximately 2500 sq feet (50 x 50 ft). Assess three sites per plot. At each site assess five plants or make a “row” assessment.
- Supporting plot data need only be entered once and should include the host name, host density, land use type, and the land unit acreage.
- Record for each inspection visit: date, disease severity, lesion type and sporulation (Y/N).
- Disease severity should be assessed at the three sites in the plot using the following categories. Absent, low, medium, high. A key to disease severity classes will be available on the SBR restricted web site.

Data uploading

There are three options for data uploading to USDA Soybean Rust Monitoring and Prediction System.

1) Paper form: The data can be entered manually into the online forms located on the USDA SBR restricted web site.

2) PDA device: USDA is in the process of developing some proprietary PDA software through North Carolina State University and the information technology company ZedX, Inc. The PDA software will be available for free download from the USDA SBR restricted observer web site. The PDA software will include forms for data entry as described by the three protocols in the framework. The PDA software includes the capability for uploading of both data and pictures.
3) File transfer. The data can be sent to USDA in Comma Separated Value (CSV) or MS Excel formats. A template will be available for downloading from the web site. The format for the data should include: observer id number, date, latitude (decimal degrees), longitude (decimal degrees), presence (0 = absent, 1 = present) and PCR confirmation (0 = no, 1 = yes).

ii) Mobile field monitoring teams

The function of the mobile monitoring teams is to help calibrate the predicted spore deposition and infection as estimated by an aerobiological model by observing disease incidence. This calibration enables model output to be used with greater confidence by stakeholders. Observations are used to define new source areas to begin the model forecast run for each day.

General information

It is suggested that at least six mobile teams should be deployed and maintained at an estimated cost of $30,000 per team during per season. The total cost for the 2005 growing season would be $180,000. The location of the teams is shown in Table 2.

Table 2. Breakdown of regions for soybean rust mobile monitoring teams.

Region	States	Proposed Regional Coordinator(s)	Possible Location of mobile team
1. Delta/ Southern Plains	LA, MS, AR, TX, OK, TN, KY	John Rupe, AR Don Hershman, KY	LA
2. South Eastern	FL, GA, SC, AL, NC, VA	Ed Sikora, AL Don Hershman, KY	GA
3. Corn Belt	IA, IL,IN, OH, MO, KS	X.B Yang, IA Dean Malvick, IL	IL
4. North East	PA, NY, MD, DE, WV, NJ	Eric De Wolf, PA	?
5. Great Lakes/ Northern plains	NE, SD, ND, WI, MI, MN	Loren Giesler, Craig Grau, WI	IA or NE
Total	**31**		

- Deployment refers to the period of time when a mobile team is active and will respond with a field survey.
- Mobile teams are deployed beginning with the first soybean emergence in their state or region. Their deployment ends once the pattern of initial spore deposition and infection incidence has been established.
- Either soybean or alternative hosts may be used for the mobile survey.
- The disease forecast models will be available on the web and will include models provided by USDA, Iowa State University and NCSU University. The USDA model will predict spore deposition ranging from light to heavy on a logarithmic scale. In the days following deposition the model will track infection severity based on weather-driven epidemiological model (see prediction section for more details).
- Mobile teams must seek diagnostic confirmation of suspected positive observations if soybean rust has not had previous laboratory confirmation in that state. New state confirmations should be confirmed by sending samples to the APHIS-PPQ National Identification Services, but only through the State and/or Land Grant University (NPDN) lab as a first screen (see Federal/State Responsibility for Identification of Phakopsora pachyrhizi, USDA-APHIS-PPQ, December 6, 2004, revised May 2, 2005.
(Appendix B or http://www.aphis.usda.gov/ppq/ep/soybean_rust/sbridv4.pdf).
Ongoing laboratory diagnosis can be provided by state and/or Land Grant University National Plant Diagnostic Network (NPDN) labs.

Specific information:

- Plots should be approximately 2500 sq. feet (50 x 50 ft). Assess three different sites (stops) within each plot. The sites should be in a v-shape and not a straight line.
- Mobile surveys should transect the predicted spore deposition and infection severity plume from the model. Replicated plots should be assigned to different spore deposition classes including zero.
- For a normal mobile survey, a row-based evaluation should be made with disease severity observations made in the crop at three heights (low, middle and high).
- Another option is to collect a more intensive data set that can be used for scientific research. The research protocol assesses rust severity at three sites per plot and five plants per site. Disease severity is rated on each node beginning on the lowest attached leaf and ending with the youngest fully expanded leaf.
- Predicted spore depositions and infection should be checked approximately 9, 12, 15 and 18 days after deposition or at the discretion of the mobile team leader.
- Supporting plot data needs only to be entered once by the scout. Information needed is: GPS location, cultivar description/name, planting date, row spacing, planting density and field acreage.
- During each inspection visit the date, plant height, degree of canopy closure, and the vegetative and reproductive growth stages will be recorded.

- Disease severity should be assessed using the following categories. Absent, low, medium, high. A key to disease severity will be available on the restricted SBR site.

Data uploading

There are three options for data uploading from mobile teams to USDA Soybean Rust Monitoring and Prediction System database.

1) Paper form: The data can then be entered manually on the USDA SBR web site using the on-line forms.
2) PDA device: USDA is in the process of developing some proprietary PDA software through North Carolina State University and the information technology company ZedX. The PDA software will be available for free download from the USDA SBR Restricted observer web site. The PDA software will include forms for data entry as described by the three protocols in the framework. The PDA software includes the capability for uploading of both data and pictures.
3) File transfer. (For presence or absence data only). The data can be sent to USDA in Comma Separated Value CSV or MS Excel formats. The format for the data should be observer id#, date, latitude (decimal degrees), longitude (decimal degrees), presence (0 = absent, 1 = present) and PCR confirmation (0 = no, 1 = yes).

iii) Industry monitoring

Industry monitoring refers to survey data collected in commercial soybean production fields as part of commercial services, research or variety trials or extension programs that are conducted with an industry sponsor/partner. The data may be collected by extension agents, field agronomists, crop consultants or individual growers. The industry data provides additional confirmation of the spatial extent of disease spread as a supplement to other survey data.

General information:

- It is anticipated that the industry data will record the "presence or absence of SBR", although industry collaborators may also collect more detailed information if required.

- Estimation of the current distribution of cooperating industry scouts is provided below (Table 3).

- Industry monitoring data may be provided as a diagnostic sample through the National Plant Diagnostic Network (NPDN).

- New state confirmations should be confirmed by sending samples to the APHIS-PPQ National Identification Services, but only through the State and/or Land Grant University (NPDN) lab as a first screen (See Appendix B - Federal/State Responsibility for Identification of Phakopsora pachyrhizi, USDA-APHIS-PPQ, December 6, 2004; revised May 2, 2005, or at the URL http://www.aphis.usda.gov/ppq/ep/soybean_rust/sbridv4.pdf). Ongoing laboratory diagnosis can be provided by state and/or Land Grant University National Plant Diagnostic Network (NPDN) labs.

Table 3. Partial list of cooperating agricultural companies and industry organizations.

Company and Industry Organizations	Key Contacts
Agreliant Genetics	Robert Waller
American Seed Trade Association	Dick Crowder
Bayer Crop Science	Jim Bloomberg
Beck's	Denny Cobb
Dairyland Seed Co., Inc.	Hunt Wiley
Delta & Pine Land Company	Kelly Whiting
Diener Seeds	Mike Diener
Harris Moran	Chester Kurowski
Hornbeck Seed Co., Inc.	Terry McCullars
Hyland Seeds	Henry Olechowski
Indiana Crop Improvement Association	Joe Deford
Monsanto	Andrew Nickell, Scott Stein
Pioneer	Bill Dolezal Wolfgang Schuh, Tom Hall
Royster-Clark	Greg St. Clair
Syngenta	Marshall Beatty, Marty Wigglesworth, Alison Tally

* Cooperation between USDA and individual companies are at different stages of negotiations

Specific information:

For a diagnostic sample

- Required information: The date, county, and presence or absence of the disease.

For an incidence only survey

- Required information: observer ID, plot ID and the location.

- During each inspection visit record the date, plant height, degree of canopy closure, and the vegetative and reproductive growth stages.
- Incidence of the disease is simply recorded as present or absent.

For a disease severity based assessment

- Plots should be approximately 2500 sq. feet (50 x 50 ft). Assess three different sites (stops) in each plot. The sites should be in a v-shape not a straight line.
- Supporting plot data needs only to be entered once by the scout. Information needed is: GPS location, cultivar description/name, planting date, row spacing, planting density and field acreage.
- Observations should be made in an unsprayed plot or if that is not possible, in an unsprayed strip.
- During each inspection visit record the date, plant height, degree of canopy closure, and the vegetative and reproductive growth stages.
- Assess three different sites (stops) at each location. A row-based evaluation should be made with disease severity observations made in the crop at three heights (low, middle and high). Alternatively an assessment can be made on five plants as described under the sentinel plot protocol.
- Disease severity should be assessed using the following categories. Absent, low, medium, high. A key to disease severity will be located on the restricted SBR web site.

There are four options for data uploading to USDA Soybean Rust Monitoring and Prediction System database.

1) <u>Laboratory sample</u>: Submission is made through a State or National Plant Diagnostic Network (NPDN) laboratory. The NPDN will provide USDA with daily data feeds of date, county, presence or absence of the disease as an Excel file or CSV format.
2) <u>Paper form</u>: The data can then be entered manually using the on-line forms located on the USDA SBR restricted web site.
3) <u>PDA device</u>: USDA is in the process of developing some proprietary PDA software through North Carolina State University and the information technology company ZedX. The PDA software will be available for free download from the USDA web site. The PDA software will include forms for data entry as described by the three protocols in the framework. The PDA software includes the capability for uploading of both data and pictures.
4) <u>File transfer.</u> (For presence or absence of disease data only). The data can be sent to USDA in Comma Separated Value CSV or MS Excel formats. The format for the data should be observer ID number, date, latitude (decimal degrees), longitude (decimal degrees), presence of the disease (0 = absent, 1 = present) and PCR confirmation (0 = no, 1 = yes).

iv) Passive surveillance through the National Plant Diagnostic Network (NPDN)

The NPDN is a collective of Land Grant University (LGU) plant disease and pest diagnostic facilities from across the United States and is coordinated by CSREES. The network allows Land Grant University diagnosticians and faculty, State Regulatory personnel, and first detectors to efficiently communicate information, images, and methods of detection throughout the system in a timely manner. Regional Centers are located at Cornell University (Northeast region), Michigan State University (North Central region), Kansas State University (Great Plains region), University of Florida at Gainesville (Southern region), and University of California at Davis (Western region). The National Agricultural Pest Information System (NAPIS) located at Purdue University has been designated as the central repository for archiving select data collected from the regions.

General information

- CSREES and its Land Grand University (LGU) partners, the NPDN and Cooperative Extension Services are preparing extension messages urging county extension agents, growers and private crop consultants to scout for SBR and to bring samples to the closest LGU diagnostic laboratory.
- In many soybean production states, growers have been trained to recognize suspected soybean rust symptoms and in diagnostic sample submission.
- Data from soybean rust samples will be uploaded to either of the 2 systems used by the NPDN which are the Plant Diagnostic Information System (PDIS) (www.pdis.org) or the Southern Plant Diagnostic Network (SPDN) database. It will be then transfer to NAPIS. The incidence data will be uploaded daily to the USDA Soybean Rust Monitoring Web site.
- It has been estimated that the additional costs for diagnostic services for soybean rust in 2005 will be $45,000 per state or $1,170,000 for 26 states. (See Appendix D for list of labs)

Protocol for sample submission

Cooperative extension agents, field scouts, crop consultants, or anyone conducting surveys of soybean rust on legume hosts, for sample submission to state or university diagnostic laboratories need to use the protocol below.

- Place the leaf, stem, or pod samples in a self locking plastic bag and store under cool conditions.

- Record the collection information (date, exact location of the field and sample location within the field, county in which collected, host plant and collector's name and phone number) on a piece of paper and include it with the sample. If the collector has a copy of the PPQ Form 391, the pertinent sections of that form should be completed and submitted with the specimen to the state or university diagnostic laboratory.

- Submit the sample through the appropriate State Department of Agriculture's diagnostic service or the land grant university's diagnostic laboratory in the state in which the sample was collected. Do not send suspect samples directly to the USDA Beltsville laboratory.

- A list of university diagnostic laboratories is available at the American Phytopathological Societies directory website: http://www.apsnet.org/directories/univ_diagnosticians.asp

- State Department's of Agriculture contacts are available at the National Plant Board website: http://www.nationalplantboard.org/

- A 48-hour turnaround time is anticipated for diagnosis and communication of the results for soybean rust samples.

- Samples submitted to the NPDN diagnostic clinics and diagnosed either as positive or negative for SBR will be entered and uploaded via the NPDN communications systems every 24 hours to a data repository in the National Agriculture Pest Information System (NAPIS).

v) International monitoring

International monitoring efforts are being coordinated by Doug Luster, ARS. The focus of international monitoring will be in Mexico and the Caribbean, with particular emphasis on regions which may provide a source of wind-blown rust spores early in the Northern Hemisphere growing season that could impact the U.S. on an annual recurring basis.

- The NPDN has established a state-equivalent plant diagnostic laboratory in the Southern Plant Diagnostic Network (SPDN) at the University of Puerto Rico, Juana Diaz, PR.

- Locations in the Caribbean (Dominican Republic, St. Thomas) and Mexico (Yucatan peninsula) will be surveyed for rust by Dr. Jose Hernandez, USDA ARS Systematic Botany and Mycology Laboratory, Beltsville, MD. No plans are yet in place to include Cuban agricultural scientists in monitoring rust outbreaks.

- Pioneer also has diagnostic capability in Salinas, Puerto Rico Diagnostic Laboratory. The contact there is Isabel Marrero (isabel.marrero@pioneer.com). The laboratory has a digital diagnostic linkage with their Johnston, IA laboratory. Additionally, Pioneer maintains a laboratory in Puerto Vallerta which will also monitor for soybean rust. Pioneer maintains staffing throughout Mexico which may contribute to a limited passive surveillance program.

vi) Spore sampling in rain

A sixth component of monitoring will be spore sampling in rain to assist in early detection and model calibration by determining observed spore deposition concentrations and timing prior to symptom development in the field. Most likely the movement of *Phakopsora pachyrhizi* (SBR) urediniospores from the southern plains will follow the same route as wheat rust urediniospores. Wheat stem rust fungus (*Puccinia graminis*) over winters along the Gulf Coast on fall planted winter and volunteer wheat, generally below latitude 30^{o} N. Disease in this area serves as inoculum for winter wheat planted in southern and central U.S and spring wheat in the northern plains. Urediniospores move northward as prevailing air movement is from south-to-north during the growing season, especially in the Great Plains. From south to north, the time of first observed disease in this "Puccinia Pathway" spans from late April (Texas) to early July (North Dakota).

Movement of rust spores along the "Puccinia pathway" has been studied using several different methods including trap plots and spore collectors. Examination of rain samples was shown to be the most reliable method for predicting first wheat stem rust infections dates in the Northern Plains. Real-time PCR methodology now allows for rapid and more precise identification of plant pathogens. A PCR assay has been developed by Dr Les Szabo (USDA ARS Cereal Disease Lab and University of Minnesota) to detect wheat stem rust urediniospores in rain samples. The lower limit of the current assay is about 10 spores per half-filter sample. The PCR method developed for *Puccinia* will now be adapted for soybean rust. It is proposed to develop a national sampling program using 124 National Atmospheric Deposition Program sites (Figure 5). Samples will be collected weekly and mailed to a central processing lab (NADP, Illinois State Water Survey) where they will be filtered. Filters will be sent to Dr. Szabo's lab for analysis on a weekly basis.

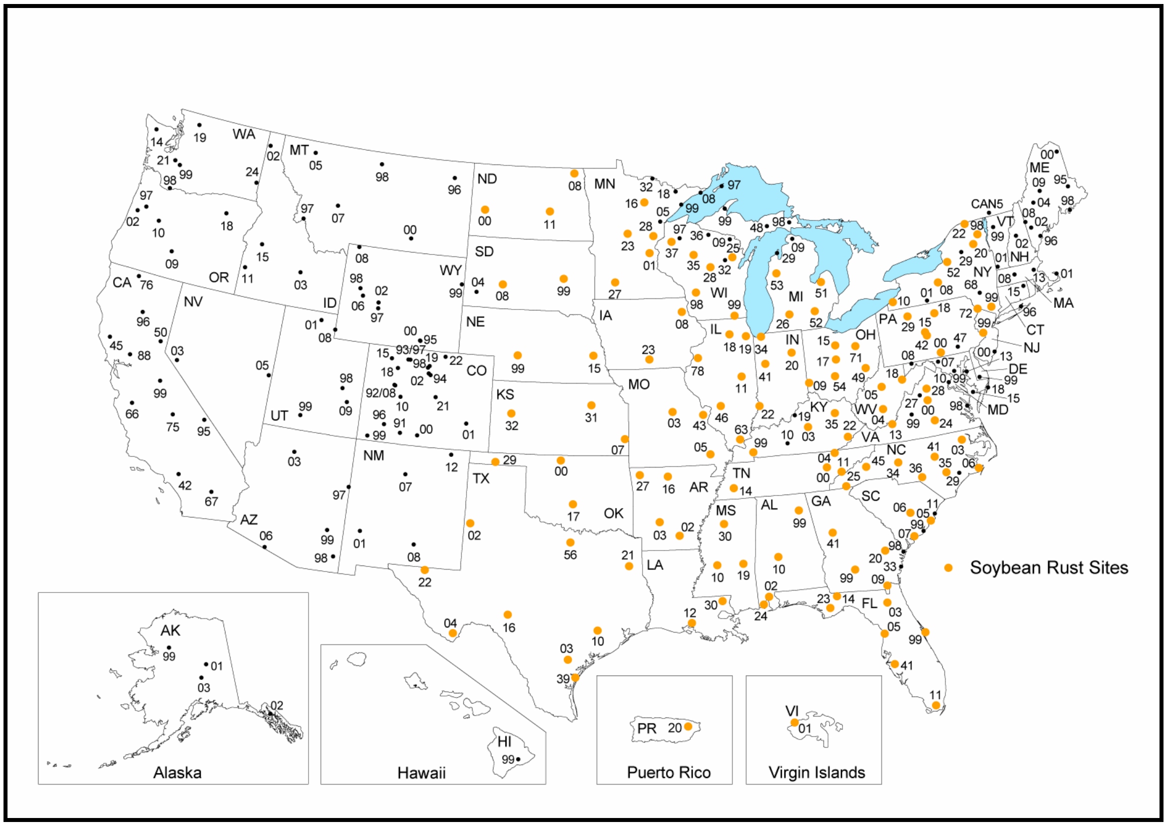

Figure 5. National Atmospheric Deposition Program collection sites for soybean rust (http://nadp.sws.uiuc.edu/).

The cost of the national sampling program is expected to be about $300,000. Considerable progress has been made by Dr. Szabo in securing funding and developing the sampling and analytical protocols to make the program successful. The spore deposition data collected by the program will be relayed by file transfer protocol to the Soybean Rust Monitoring and Prediction System where the results will be displayed as weekly maps.

2. Information management of decision criteria, observations of soybean rust, and predictive model output to stakeholders. (USDA Soybean Rust Monitoring and Prediction System)

A USDA SBR web site has been created to disseminate information to stakeholders (Figure 6). The URL address for the site is www.usda.gov/soybeanrust

- The USDA site (Soybean Rust Monitoring and Prediction System) is a collaborative project between Penn State University, North Carolina State University and the information technology company ZedX, Inc.

- The USDA web site is comprised of separate public, specialist, researcher and observer views although only the public site is available without an ID and password.
- The web-sites feature a user interface which is zoomable from the national to the sub-county scale.
- A calendar will allow users to see the daily progression of disease severity and crop phenology and allows users to move forward or backwards through time.
- Reference overlays include interstate highways, soybean growing areas, county boundaries and major cities.

Public Site

- Viewers on the public site will see maps of disease management recommendations, survey observations and scouting to the county scale. (Figure 6)
- Each map is controlled at the county scale by the state specialist. Public viewers will NOT see model output but only state specialist interpretation of it under a commentary section on the page. The web site will be linked from the USDA website. It is also hoped that the site will be linked from Land Grant University web pages and IPM centers.

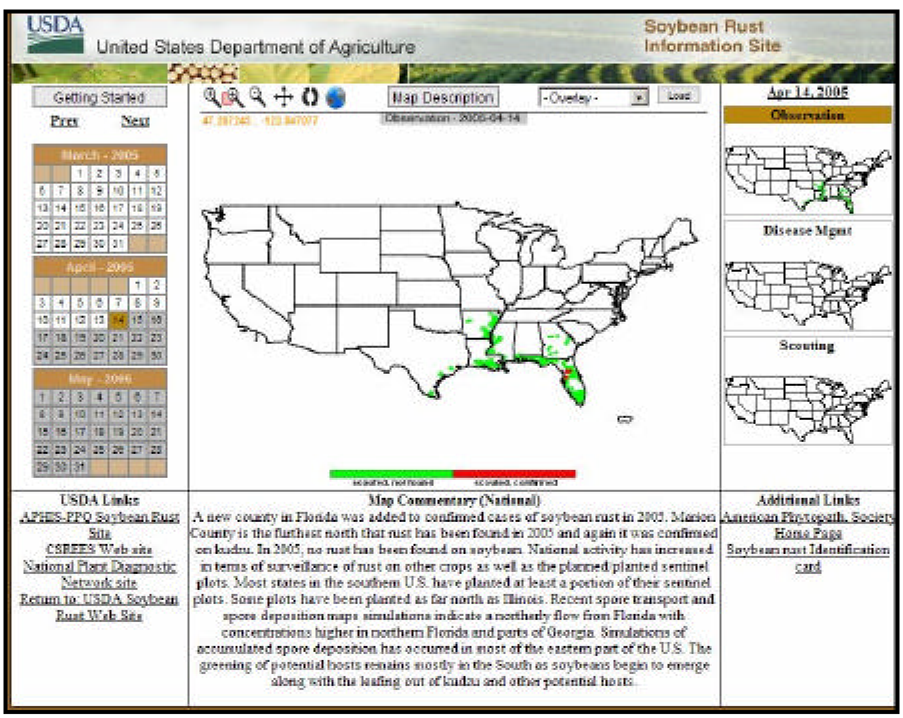

Figure 6. A view of the public USDA soybean rust web interface. The main features of the interface are a calendar, a zoomable map, national commentary, and disease management and scouting information.

Restricted Sites – Observer, specialist, researcher, and industry sites.

- The researcher, observer and specialist views display observed and predicted disease severity and spore deposition. Predicted disease severity will be shown as a color scale from nil to severe based upon the proportion of diseased leaf area. Latent infections (those that have not yet appeared) will also be indicated on the color scale. The predicted and observed severity will use the same color coding scheme.
- Observations will be displayed on the map using symbolic and color coding. Symbolic coding (e.g. +, o, □, ?) will distinguish observations of different survey protocols (e.g. sentinel, mobile, NPDN and industry). Color coding will be used to distinguish disease absence, presence (unconfirmed), presence (confirmed), pending and disease severity.
- The observer site allows uploading of data to the USDA web site. The specialist site allows a state specialist to control what information is displayed at county scale in their state. The researcher site allows soybean pathologists to conduct epidemiological research and provide advice to specialists. Industry cooperators will have a site that will allow them to see and download a restricted set of observations, data input and model output.
- Observers will be provided with user ID and password to USDA SBR web site.
    - PDA users: PDA software is available for downloading from USDA web site. Uploading of data will be by synching the PDA to a computer.
    - Other users: Excel spreadsheets with data templates can be downloaded from the USDA observer website. Observations are entered into the spread sheet which can then be uploaded as CSV file. Alternatively, an online web form can be filled out.
- Interpretations and commentaries for the public maps will be provided by a national ARS specialist. When a user clicks on an individual state, an interpretation from the designated state soybean specialist will also appear if one exists otherwise the national commentary will appear.

Information and Data Infrastructure

The diagram below (Figure 7) graphically illustrates the data and information flow from sample submission to and through the labs and dissemination of that information.

Information flow begins with sample submission and data collection (yellow shading), regulatory reporting (purple shading), information management including interpretation (blue shading) and ending with outreach (green shading).

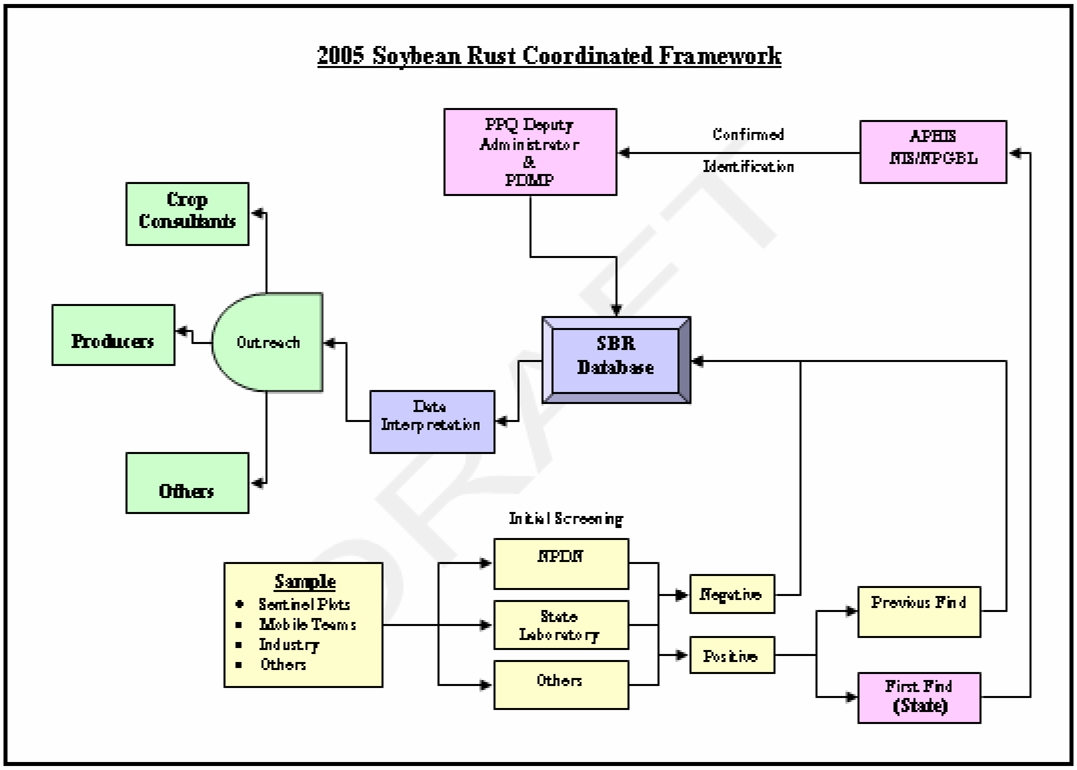

Figure 7. Information infrastructure for soybean rust from the perspective of sample submission and data flow.

Information flow can be described from the perspective of data flow beginning with data collection at the top and proceeding through diagnostics, data archiving, data integration, interpretation, and dissemination (Figure 8). Shown in the figure is agency involvement in each aspect of surveillance and monitoring for SBR in the United States and the resulting data and information flow through to the SBR websites.

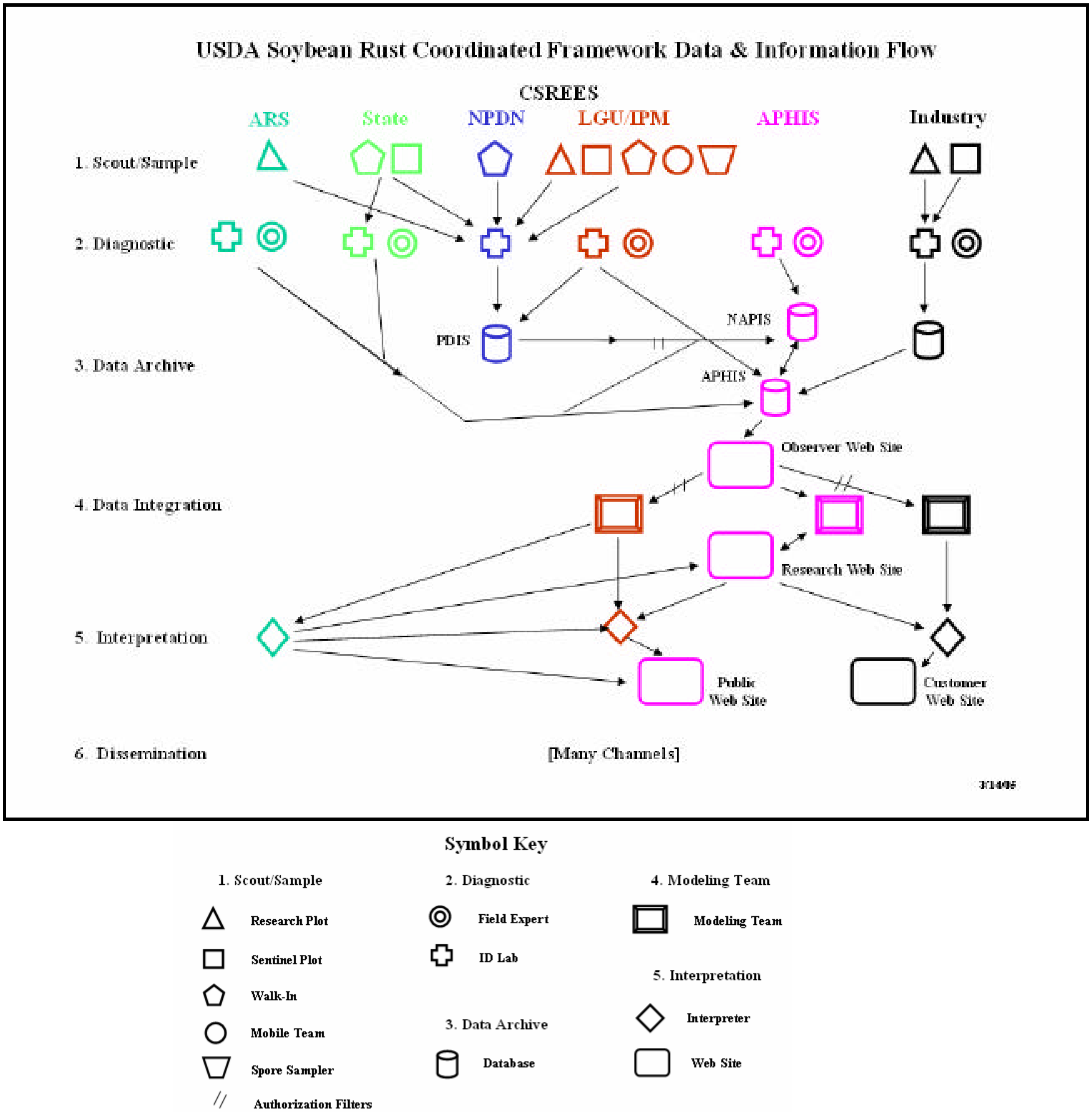

Figure 8. USDA Soybean Rust Information Data Flow and Information Diagram

3. Decision criteria for fungicide application.

Fungicides will be the primary tools in the management of soybean rust in the United States. Guidelines for managing the disease are based on data from Africa and South America where it was found that the crop should be protected from the flowering stage through the grain fill stage. The most effective management programs were those that were preventative: that is, where the first application was applied before soybean rust was seen in the field. The efficacy of the products available in the U.S. (under either Section 3 or Section 18 registration) has been proven in trials in South America and Africa. The products that have proven efficacy include chlorothalonil, strobilurin and triazole products.

Each product has different strengths and weaknesses and they differ in how and when they should be used to manage soybean rust. None of the products can eradicate the fungus. The triazole products have curative activity (can inhibit but not eradicate existing infections) and are protectants while the chlorothalonil and strobilurin products only are protectants and only prevent new infections. The chlorothalonil and strobilurin products need to be applied before infection, and once the disease exceeds 1% incidence, yield losses may occur even with a subsequent application of a strobilurin product. Triazole products can be applied prior to or after the disease appears, but once the disease is at a 10% incidence or is in the mid-canopy, yield loss will be expected.

Monitoring the fields will be critical in the decisions of when and what fungicides to apply. Predictive forecasting, although in its first year of validation and testing may also provide useful data for decision making. Based on experience in South America and South Africa, a typical management program may require two application of fungicides based on phenology of the plant at the reproductive growth stages. The first application is at growth stage R1-R2 and the second 14 to 20 days later. The program could also be based on a calendar with the first application at 50 days after planting and the second 14 to 20 days later. Monitoring data and predictive forecasts could be used to time fungicide applications, thereby possibly delaying the first application and/or eliminating the second.

Decision criteria are influenced by many factors:

- Soybean rust is a rapidly spreading disease. Studies in Africa and South America have demonstrated that fungicides need to be applied before or as soon as the disease is detected in a production field.
- Late diagnosis of the disease could result in substantial crop loss. If heavy spore deposition occurs along with spore germination and colonization, it may be too late to effectively control the disease.
- Crop loss may occur if fungicides are applied late and if few curative fungicides are available.
- The disease is difficult to observe and can be mistaken for other disorders or diseases.
- Soybean rust treatments should be applied at approximately 50 days after planting and 14 to 20 days later. An application should only be missed if disease was

absent from the production area. If spore showers are likely then these treatments are essential regardless of whether disease has been yet observed in the actual grower field.

- By using ground-trusted prediction models there is potential to provide decision information to producers and other decision makers well before disease is observed in local fields and in time to apply timely and effective fungicide treatments.

Other comments

- To help evaluate the management program, growers should be encouraged to leave a strip of the field unsprayed and mark it clearly.

- Risk communication efforts would be made before the 2005 growing season by land grant university extension personnel to educate soybean producers on many issues including;

  i. the correct interpretation of monitoring data and predictive models;
  ii. the limitations and uncertainties associated with monitoring systems and predictive models;
  iii. decision criteria and risk management; and
  iv. fungicide selection and timing

4. Predictive models

- The Soybean Rust Aerobiology Prediction System (SRAPS) is collaborative project between Penn State University, North Carolina State University and the information technology company ZedX, Inc.
- The Soybean Rust Prediction System (SRPS) displays predicted rust severity at a 10 km^2 resolution across North America.
- The components of the (SRPS) model include: (i) source area delineation based on soybean crop and kudzu distributions, (ii) overwintering survival of rust in source areas, (iii) NDVI-calibrated, temperature-driven greening function for North America, (iv) evaluation of spore aerial transport potential using data sets derived from the National Weather Service including pressure, wind and temperature fields with 6 hour resolution and corresponding cloud cover and precipitation records, (v) soybean crop growth model driven by daily temperature and precipitation data from past 5 years, and (vi) soybean rust epidemiology model driven by daily temperature and leaf wetness data from past 5 years.
- Observations primarily from sentinel plots will be used to quantify the distribution of spore production in domestic and off-shore source regions.
- The system will display observed and predicted disease severity and spore deposition. Predicted disease severity will be shown as a color scale from nil to severe based upon the proportion of diseased leaf area. Predicted

latent (infected but not yet appeared) will also be a severity class. The predicted and observed severity will use the same color coding scheme.

- The North American Disease Forecast Center at NCSU will also provide disease forecasts using the HYSPLIT modeling system. The forecasts will be similar to those it has provided operationally for nine years.
- Iowa State University is also in the process of developing forecast models and will participate in the national forecasting efforts. Predicted daily weather data from an atmospheric model (MM5) will be used as inputs to make short term prediction of soybean rust risk in different geographic areas.

5. Communication and Outreach

- The official USDA web-site development will be led by Kim Taylor, Director of the USDA Web Services and Distribution section. She will coordinate the site design and linkages in consultation with other USDA personnel.
- The Southern Soybean Disease Working group, NC-504, NCDC-202, and NCR-137 will be meeting in Scottsdale, Arizona on March 2nd and 3rd.
- The American Phytopathological Society will organize a symposium to be held in late fall to discuss soybean rust and the lessons learned in season 2005. APS will also facilitate real time publishing of fungicide efficacy studies
- The Plant Management Network will create a web page on Soybean Rust. Designed to provide plant science practitioners fast electronic access to proven solutions, the Plant Management Network offers an extensive searchable database comprised of thousands of web-based resource pages from the network's partner universities, companies, and associations. http://www.plantmanagementnetwork.org
- The University of Kentucky has created a SBR listserve to facilitate communication. For more details on the list serve please contact Don Herschman at (dherschma@uky.edu)
- Nebraska is establishing a Soybean Rust Hotline for its stakeholders. For more details contact Loren Giesler at the University of Nebraska. (lgiesler@unl.edu)
- A group was designated to work with the American Certified Crop Advisors to facilitate outreach Bill Hoffman at CSREES is the contact for this.

5. Funding and transition plans

The cost of the USDA framework includes outreach, monitoring, information management, predictive modeling, and developing decision criteria for fungicide applications. Outreach includes state extension, regional and national efforts. The USDA is currently evaluating funding needs and opportunities to cost-share.

In subsequent years the cost of the monitoring program can be reduced since experience with the disease will be gained. In addition, fewer monitoring observations will be needed as input to the predictive model. It is anticipated in season 2006, that the monitoring could be cut in half. By season 2007, a quarter of the original number of monitoring sites might be needed and these might realistically be provided by industry and university cooperators. A transition plan is being developed with key agency involvement for 2006.

6. Coordination and Agency Leadership

Overall Coordination of Framework

A proposed soybean rust information and hierarchal architecture is shown below (Figure 9). The structure begins at the top with a steering committee comprised of the major soybean stakeholders.

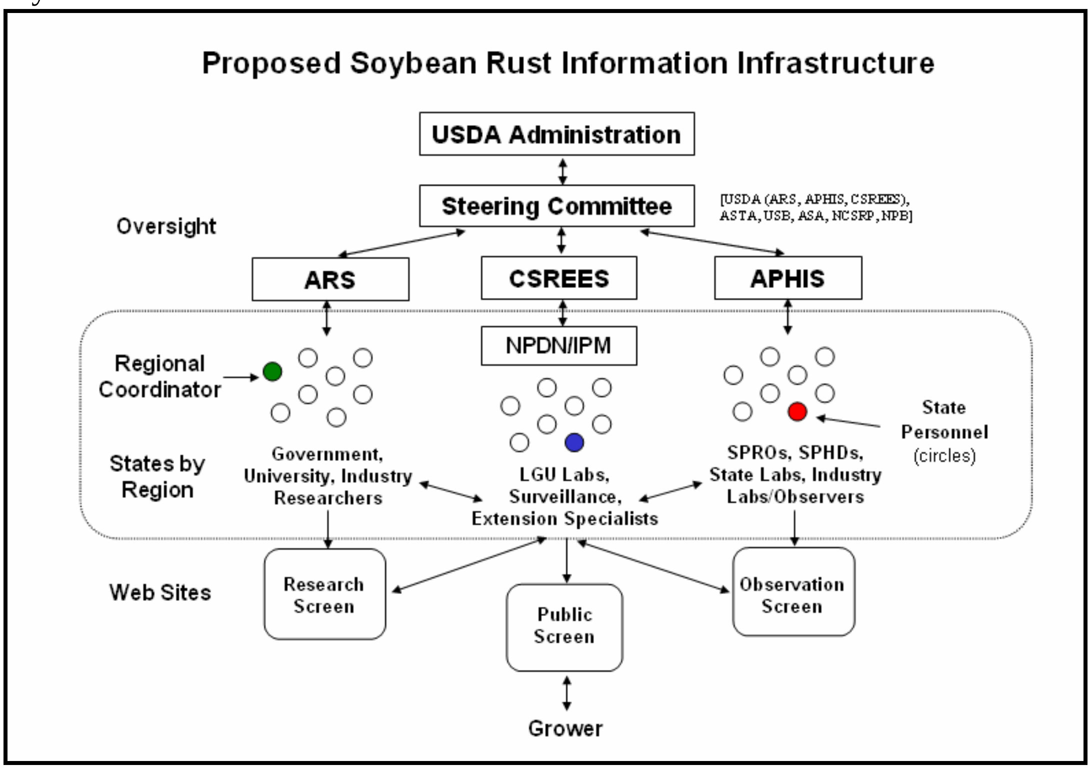

Figure 9. Proposed soybean information infrastructure from an organizational perspective.

There are three SBR National Framework Coordinators (SBR-NFC) each representing their respective USDA agency and they report at weekly or bimonthly intervals to the steering committee.

The ARS SBR-NFC coordinates the activities of government, university and industry researchers related to decision criteria, prediction modeling and surveillance. The CSREES SBR-NFC coordinates the NPDN (National Plant Diagnostic Network) and outreach and evaluation through Integrated Pest Management Centers and through Land Grant University Extension services. The APHIS SBR-NFC coordinates the information management and surveillance systems through APHIS regional and state personnel and cooperators. Underneath the National coordinators is a network of Regional Framework Coordinators (SBR-RFC). The RFCs report to their respective agency NFC with weekly or bi-monthly phone conferences.

A suggested regional structure is the USDA-ERS regions (Figure 10), although this is at the discretion of the NFCs. Although, subsequently, the Appalachia region was combined into other regions (Table 2). Below the regional coordinators are state coordinators who coordinate the relevant SBR framework activities in their state. State sentinel plot coordinators implement the sentinel program for their state while state specialist control the information that appears on their state website at the county level. State coordinators report to their respective SBR-RFC with weekly or bi-monthly phone conferences.

Regional and state coordinators may serve in multiple capacities. For example, a single individual may report to both ARS and APHIS NFCs. A complete list of state specialists and sentinel plot leaders is in Appendix A.

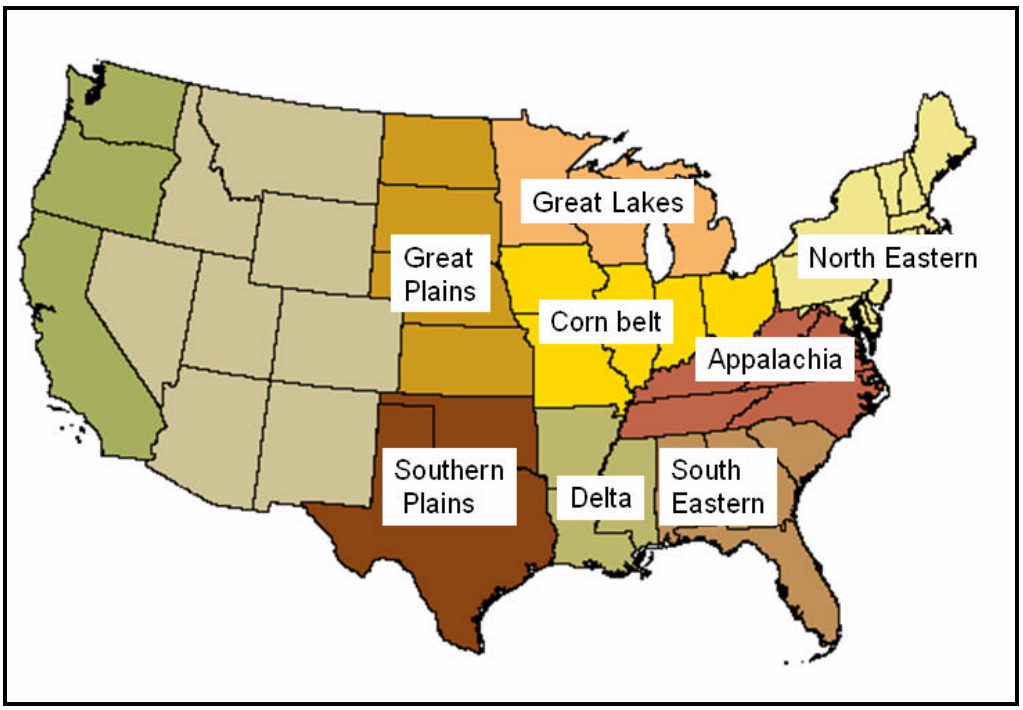

Figure 10. USDA-ERS regions.

Below the level of the state coordinators is the web interface. Individual users who are members of the three framework coordination groups can logon to the web site and see a full set of model output, interpretations and observations. Users in these groups can also upload or download observations. Pre-selected individuals in the ARS NFC group provide map interpretation which is then refined for public consumption by other users in the CSREES NFC group. The general public, including growers, are able to only view the public site which is limited to confirmed and negative observations, simplified model output (e.g. warning, watch and wait coding), map commentaries and links to other useful web sites.

Steering Committee

- The Steering Committee will guide and evaluate the progress of attaining the objectives of the Framework (monitoring, information management, predictive modeling, outreach, and decision criteria for using fungicides.), and will provide feedback to the responsible coordinators on their respective objectives.
- The Steering Committee will include representatives from APHIS, CSREES, ARS, NPB, USB, ASA, ASTA, and NCSRP. (In other words the current Framework working group)
- The Steering Committee will hold weekly phone conferences to get updates.
- There will be three reports to the steering committee from the National coordinators for i) ARS, ii) CSREES, and (including data uploading and downloading issues); iii) APHIS.

Duties of ARS NFC The ARS NFC coordinates the activities of government, university and industry researchers related to decision criteria, prediction modeling and surveillance. The proposed ARS SBR-NFC is Glen Hartman, ARS.

The National Coordinator will:

- Compile a list of soybean specialists coordinating information dissemination in each state. This list includes the NC-504 soybean rust group.
- Work with Anne Dorrance and NC-504 to coordinate documents related to fungicide application.
- Review monitoring observations and predictions weekly with regional coordinators.
- Supervise the dispatch of mobile teams.
- Supervise and coordinate the use and application of prediction models.
- Write at least weekly interpretations of the soybean rust monitoring and prediction web site. Work with NC-504 to create a pre-season interpretation guide to assist stakeholders in use of the web site.
- Be responsible for having the regional and state coordinators write additional interpretation messages for their regions and states as needed.

- Lead weekly or biweekly phone conferences with regional coordinators.

Duties of CSREES SBR-NFC. The CSREES NFC coordinates the NPDN (National Plant Diagnostic Network) and outreach and evaluation through Integrated Pest Management Centers and through Land Grant University Extension services. The proposed National Coordinator is Kitty Cardwell.

The National Coordinator will:

- Coordinate the SBR diagnostic activity of the NPDN.
- Oversee evaluation of user acceptance of the Soybean Rust Monitoring and Prediction Web site. Bill Hoffman, Stuart Kuehn and Loren Giesler volunteered for this task. Create focus groups consisting of farmers, industry representatives, agronomists, and crop consultants etc to evaluate the Soybean Rust Monitoring and Prediction web site's ease of use.
- Coordinate outreach and extension through Regional IPM centers.
- Coordinate diagnostic workshops and training, fungicide application education, printing of a fungicide manual, reprints of the SBR ID card, training videos/DVD, reprinting the SBR Pest Alert, adequately supporting the NPDN infrastructure to assure surge capacity is accommodated (i.e. calc. 2000 samples to be processed by each lab in 26 States, within a two week period at peak season), in-field application technology education material, fungicide efficacy demonstration, and an epidemiological education resource guide needs to be developed and distributed.
- Bimonthly or weekly conference calls as needed with NPDN and IPM centers.
- Coordinate scenario training exercises for state specialists on May 3 in St Louis. The SBR web site will be used as a tool to conduct the training session. The purpose of the training is to see if specialists make provide comparable management guidelines across states, regions and times of year. Risk management and insurance issues will be incorporated.

Duties of APHIS SBR-NFC coordinator. The coordinator will oversee the sentinel plots, mobile monitoring teams and industry monitoring. In addition the APHIS national coordinator will supervise several components of information management. The proposed national coordinator is Coanne O'Hern.

The national coordinator will:

- Convene phone conferences with individual states to initiate the surveillance and information management program in each state.
- Create and implement a regional framework for surveillance and information management (Table 1 and 2).
- Allocate funding to support the national surveillance program.
- Assist states to coordinating with industry and crop consultants to supply monitoring data.
- Create an informal manual describing the monitoring protocols including a list of non-soybean hosts.
- Assist regional coordinators in dealing with technical issues relating to data uploading from diverse sources.
- Lead weekly or biweekly phone conferences with regional coordinators.
- Supervise the development of the Soybean Rust Monitoring and Prediction web site, including the PDA tool, data uploading and technical support.
- Supervise the development of the USDA Soybean Rust Prediction model.

Duties of APHIS Technical Support Specialist

APHIS will provide a national technical support specialist (SRMP-TSS) for data uploading and downloading from the SRMP site. The specialist will work with regional monitoring coordinators to address and communicate data uploading and down loading issues. The specialist will report to the APHIS SBR-NFC.

The Specialist will:

- Assist in writing a tutorial for use of SRMP web site.
- Coordinate with researchers who want to receive the monitoring data and use the research site.
- Test PDA software for industry, sentinel plots and mobile program.
- Implement a File Transfer Protocol for receiving CSV or Microsoft Excel files for industry, sentinel plots and mobile program.
- Implement a file transfer protocol so University and USDA researchers can download monitoring data.
- Implement a protocol for display of monitoring observations. This includes ensuring data is not reported twice and suspect data is eliminated or flagged as questionable.

Duties of Regional Coordinators

The responsibilities of the "soybean rust regional coordinator" is (1) to periodically inform the Steering Committee of the status of operations and the performance of cooperators at the state level and (2) to communicate directly with the national coordinator on a day-to-day basis. The regional coordinators are responsible for state "specialists" in their respective regions (Table 2).

The Regional Specialists will:

- Participate in weekly conference calls with the APHIS National Survey Program Leader, the APHIS database manager, and the ARS interpretation specialist.
- Identify the appropriate state specialists and sentinel plot coordinators and substitutes. (NB: there may be two state coordinators for sentinel plots, USDA and NCSRP but in most cases there will be a single coordinator for sentinel plots).
- Facilitate (weekly or bimonthly) regional conference calls with state specialists and sentinel plot coordinators to address any operational issues.
- Implement and coordinate protocols for the soybean rust web site:
  i) Monitoring;
  ii) Data uploading - (PDA and forms)
  iii) Information management for state specialists.
- Develop "mutual aid" procedures among the state specialists. It is necessary to provide backup between specialists in cases of illness, vacations etc.
- Coordinate the training of state specialists.
- Notify state specialists of any technical problems or informational errors as received from either the "data manager," national coordinator, steering committee coordinator, or supervisor.

Duties of the State Soybean Rust Specialist

The responsibilities of the state soybean rust specialist is to control and update the maps and other information for their respective state so that it appears on the USDA SBR Public web site.

The Specialist will:

- Control the observation, scouting and disease management commentaries on the USDA SBR public web site.

- Update daily, the public observation map by checking the observation map available from the specialist web sites. They will also update the PDF file describing the confirmed observations in the state.
- Update the public scouting map three time per week by checking the simulation scouting map available from the specialist web site. Protocols are found under the “tools” button on the web site.
- Update the management recommendations maps as needed using the simulation scouting and disease severity maps and create a PDF file to describe management recommendations/commentaries.
- Create and edit web links to state soybean rust pages for display on the USDA SBR public web site.
- Participate in regional conference calls and email correspondence with state coordinators to address any operational issues.
- Communicate with state coordinators of sentinel plots and diagnostic labs.
- Implement “mutual aid” procedures among other state specialists. It is necessary to provide backup between specialists in cases of illness, vacations etc.

6. Summary

- The five components of the plan are: 1) an operational surveillance and monitoring network; 2) a web-based system for information management; 3) decision criteria for fungicide application; and 4) predictive modeling and 5) communication and outreach.

- The monitoring component includes sentinel plots, mobile surveys and spore sampling. Sentinel plots provide quantification of spore production in source regions and mobile surveys provide calibration of predicted model output with disease observations.

- Fewer monitoring resources will be needed in seasons 2006 and 2007. A transition plan should incorporate university and industry cooperators to provide the required monitoring resources. USDA transition plans are covered in a separate document.

APPENDIX A

State Specialists Responsible for Interpretation

States	Team*	Lead contact	Affiliation	E-mail	Region
Alabama	Ed Sikora	Lead	Auburn University	sikorej@auburn.edu	SE
Arkansas	Ples Spradley	Lead	University of Arkansas	pspradley@uaex.edu	Delta
	Rick Cartwright		University of Arkansas	rcartwright@uaex.edu	Delta
Colorado	Howard Schwartz	Lead		howard.schwartz@colostate.edu	Western
Delaware	Faith Kuehn	Lead	State Department of Agriculture	Faith.kuehn@state.de.us	NE
Florida	Jim Walker	Lead	FL Department of Agriculture	<walkerj1@doacs.state.fl.us>	SE
	Tim Schubert		FL Department of Agriculture	<schubet@doacs.state.fl.us>	SE
	Wayne Dixon		FL Department of Agriculture	dixonw@doacs.state.fl.us	SE
	Bryan Benson		FL Department of Agriculture	bensonb@doacs.state.fl.us	SE
	James Marois		University of Florida, Quincy, Fl 32351-9529	marois@mail.ifas.ufl.edu	SE
	Carrie Harmon		University of Florida, Gainsville, FL	clharmon@ufl.edu	SE
Georgia	Bob Kemerait	Lead	University of Georgia • Athens, GA 30602-7274	Kemerait@uga.edu	SE
	Dan Phillips		University of Georgia • Athens, GA 30602-7275	dphilli@griffin.uga.edu	SE
	Phillip Joust		University of Georgia	pjost@uga.edu	
Idaho					Western
Illinois	Linda Kull	Lead	University of Illinios	lkull@uiuc.edu	CB
	Dean Malvick		University of Illinios	dmalvick@uiuc.edu	CB
	Jason Bond		South Illinois University	jbond@siu.edu	CB
Indiana	Greg Shaner	Lead	Purdue University	shanerg@purdue.edu	CB
Iowa	Paula Flynn	Lead	Iowa State University	pflynn@iastate.edu	CB
	Christina Englebrecht		Iowa State University	cengel@iastate.edu	CB

	X.B. Yang		Iowa State University	xbyang@iastate.edu	CB
	Alison Robertson		Iowa State University	alisonr@iastate.edu	CB
Kansas	Doug Jardine	Lead	Kansas State University	jardine@plantpath.ksu.edu	CB
Kentucky	Don Hershman	Lead	University of Kentuky	dhershma@uky.edu	Delta
Louisiana	Clayton Hollier	Lead	LSU AgCenter	chollier@agctr.lsu.edu	Delta
	Ray Schneider		LSU AgCenter	rschnei@lsu.edu	Delta
Maryland	Arv Grybauskas	Lead	University of Maryland	arvydas@umd.edu	NE
Michigan	Ray Hammerschmidt	Lead	Michigan State University	hammers1@msu.edu	GLNP
Minnesota	Jim Kurle	Lead	University of Minnesota	kurle001@umn.edu	GLNP
Mississippi	Emily Rose	Lead	Mississippi State University	erose@pss.msstate.edu	Delta
	Alan Blaine		Mississippi State University	ablaine@pss.msstate.edu	DElta
Missouri	Laura Sweets	Lead	University of Missouri	SweetsL@missouri.edu	Corn Belt
Nebraska	Loren J. Giesler	Lead	University of Nebraska, Lincoln, NE 68583-0722	lgiesler1@unl.edu	GNLP
New Jersey	Ann Gould	Lead	Rutgers University	gould@aesop.rutgers.edu	NE
New York	Gary C. Bergstrom	Lead	Cornell University	gcb3@cornell.edu	NE
	Mary McKellar		Cornell University	mem40@cornell.edu	NE
North Carolina	Stephen Koenning	Lead	North Carolina State University	stephen_koenning@ncsu.edu	SE
	Jim Dunthie		North Carolina State University		SE
North Dakota	Carl A. Bradley	Lead	North Dakota State University	cbradley@ndsuext.nodak.edu	GNLP
	Kasia Kinzer		North Dakota State University	kasia.kinzer@ndsu.edu	GNLP
Ohio	Anne E. Dorrance		Ohio State University	dorrance.1@osu.edu	CB
Oklahoma	John Damicone	Lead	Oklahoma State University	jpd3898@okstate.edu	
	Patricia Bolin		Oklahoma State University	bolinp@okstate.edu	Delta
Oregon					Western
Pennsylvania	Erick De Wolf	Lead	Penn State University	edd10@psu.edu	NE
Puerto Rico	Consuelo Estevez de Jensen	Lead		Consuelo@umn.edu	GNLP
South Carolina	John Mueller	Lead	Clemson	JMLLR@clemson.edu	SE

South Dakota	Martin Draper	Lead	South Dakota State University	Martin.Draper@sdstate.edu	GNLP
Tennessee	Beth Long	Lead	University fo Tennessee	<ealong@utk.edu>	DElta
	Melvin A. Newman		University fo Tennessee	manewman@utk.edu	Delta
Texas	Tom Isakeit	Lead	Texas A&M	t-isakeit@tamu.edu	Delta
	Joe Krausz		Texas A&M	krausz@tamu.edu	Delta
	Charlie Rush		Texas A&M	cm-rush@tamu.edu	Delta
Virginia	David Holshouser	Lead	Virginia Tech	dholshou@vt.edu	SE
	Erik Stromburg		Virginia Tech	elstrom@vt.edu	SE
	Pat Phipps		Virginia Tech	pmphipps@vt.edu	SE
Washington		Lead			Western
West Virginia	Terry Carrington	Lead	WV Department of Agriculture	tcarrington@ag.state.wv.us	NE
Wisconsin	Craig Grau	Lead	University of Wisconsin	cg6@plantpath.wisc.edu	GNLP

* Individuals authorized to edit the maps and messages for each state which are displayed on the public web site are provided with a username and password.
* Lead contact is first person to call in state if maps need updating.

Sentinel Plot Teams*			
States	**Team**	**Affiliation**	**E-mail**
Alabama	Ed Sikora	Auburn University	sikorej@auburn.edu
			_
Arkansas	Rick Cartwright	Cooperative Extension Service	rcartwright@uaex.edu
	John Rupe	Department of Plant Pathology	jrupe@uark.edu
Colorado	Howard Schwartz		howard.schwartz@colostate.edu
Delaware	Faith Kuehn	Delaware Department of Agriculture	Faith.kuehn@state.de.us
Florida	James Marois	University of Florida	marois@mail.ifas.ufl.edu
Georgia	Bob Kemerait	University of Georgia	Kemerait@uga.edu
	Daniel Phillip	University of Georgia	dphilli@griffin.uga.edu
Idaho			
Illinois	Linda Kull	University of Illnois	lkull@nsrl.aces.uiuc.edu
	Dean Malvick	University of Illnois	dmalvick@uiuc.edu
	Jason Bond	South Illinois University	jbond@siu.edu
Indiana	Greg Shaner	Purdue University	shanerg@purdue.edu
Iowa	X.B. Yang	Iowa State University	xbyang@iastate.edu
	Alison Robertson	Iowa State University	alisonr@iastate.edu
Kansas	Mark Mayfield	Kansas State University	mmayfiel@oznet.ksu.edu
Kentucky	Don Hershman	University of Kentuky	dhershma@uky.edu
Louisiana	Clayton Hollier	LSU AgCenter	chollier@agctr.lsu.edu
	Raymond W. Schneider	Department of Plant Pathology	rschnei@lsu.edu
Maryland	Arv Grybauskas	University of Maryland	arvydas@umd.edu
Michigan	Ray Hammerschmidt	Michigan Styate University	hammers1@msu.edu

Minnesota	Jim Kurle	University of Minnesota	kurle001@umn.edu
Mississippi	Alan Blaine	Mississippi State University	ablaine@pss.msstate.edu
Missouri	Laura Sweets	University of Missouri	SweetsL@missouri.edu
Nebraska	Loren J. Giesler	University of Nebraska	lgiesler1@unl.edu
New Jersey	Ann Gould	Rutgers University	gould@aesop.rutgers.edu
New York	Gary C. Bergstrom	Cornell University	gcb3@cornell.edu
North Carolina	Stephen Koenning	North Carolina State University	stephen_koenning@ncsu.edu
North Dakota	Carl A. Bradley	North Dakota State University	cbradley@ndsuext.nodak.edu
Ohio	Anne E. Dorrance	Ohio State University	dorrance.1@osu.edu
Oklahoma	John Damicone	Oklahoma State University	jpd3898@okstate.edu
Oregon			
Pennsylvania	Erick De Wolf	Penn State University	edd10@psu.edu
Puerto Rico	Consuelo Estevez de Jensen		Consuelo@umn.edu
South Carolina	John Mueller	Clemson	JMLLR@clemson.edu
South Dakota	Martin Draper	South Dakota State University	Martin.Draper@sdstate.edu
Tennessee	Melvin A. Newman	University of Tennessee	manewman@utk.edu
Texas	Tom Isakeit	Texas A&M	t-isakeit@tamu.edu
Virginia	David Holshouser	Virginia Tech	dholshou@vt.edu
Washington			
West Virginia	Terry Carrington	WV Department of Agriculture	tcarrington@ag.state.wv.us
Wisconsin	Craig Grau	University fo Wisconsin	cg6@plantpath.wisc.edu

*** Individuals authorized to conduct diagnostics are provided with a password, in advance, for entering both "Survey and Diagnostics" data into the "APHIS" database**

APPENDIX B

APHIS -PPQ/Non-Federal Responsibilities for
Identification of *Phakopsora pachyrhizi*
May 2, 2005

Phakopsora pachyrhizi, cause of Asian soybean rust (SBR), was found for the first time in the United States in Louisiana, November 6, 2004. It was subsequently found in additional southeastern states on soybeans as well as kudzu. The disease is likely to spread very rapidly to other soybean-growing areas in the US during the 2005 growing season by means of windborne spores. Therefore, APHIS-PPQ is not attempting to prevent its spread via a domestic quarantine regulation. State regulatory officials, growers, extension agents, and others are very interested in quick detection of SBR in order to effectively manage the disease. In this regard, PPQ will be allowing States to conduct their own diagnostics as they deem necessary after PPQ confirms the first detection on a host in a State. Permits for importation and interstate movement of *P. pachyrhizi* and *P. meibomiae* are still required, as would be the case for any plant pest.

A number of diagnosticians within the National Plant Diagnostic Network (NPDN) and State departments of agriculture have been trained to morphologically identify *P. pachyrhizi* and they have trained first responders. A few scientists have been trained to use real-time PCR to identify *P. pachyrhizi* and differentiate it from the morphologically similar but less aggressive *Phakopsora meibomiae*. PPQ is encouraging the States to submit the first suspect samples for diagnosis through the NPDN laboratories until SBR is confirmed in a State or county during the 2005 growing season. The latter species has not been found in the continental US and therefore any *Phakopsora* species on soybean in the US is highly likely to be *P. pachyrhizi*. Ultimately, the soybean grower may not care to know if the soybean rust symptoms are caused by one or both of the *Phakopsora* species. States should decide whether identifications, after the initial PPQ-confirmed state/host records, are based on morphology, or morphology and PCR.

Responsibilities for Identifying *Phakopsora pachyrhizi*
(Revised to Apply to Various Sample Sources, April 20, 2005)

Issue	Initial Diagnostics	PPQ Confirmation	Outcome
First US observation of SBR-like symptoms in a **State**	Send sample to the diagnostic lab/authority designated by the State. If the lab/authority believes it may be SBR, a sample is sent to PPQ-NIS.	PPQ-NIS examines the sample morphologically. If *Phakopsora*, then a sub-sample is sent to PPQ-CPHST for real-time PCR.	New State record if confirmed positive by PPQ. Diagnostic authority enters record into database [PDIS, SPDN, NAPIS, or APHIS]
First US observation of SBR-like symptoms on a **host** not previously reported in a State	Send sample to the diagnostic lab/authority designated by the State. If the lab/authority believes it may be SBR, a sample is sent to PPQ-NIS.	PPQ-NIS examines the sample morphologically. If *Phakopsora*, then a Sub-sample is sent to PPQ-CPHST for real-time PCR.	New State*Host record if confirmed positive by PPQ. Diagnostic authority enters record into database [PDIS, SPDN, NAPIS, or APHIS]
First US observation of SBR-like symptoms in a **county** from a State where SBR has already been	Send sample to the diagnostic lab/authority designated by the State (Identification may be based on morphology, or both	N/A. DO NOT SEND TO PPQ	New county record. Diagnostic authority enters record into database [PDIS, SPDN, NAPIS, or

confirmed by PPQ	morphology and PCR.)		APHIS]
Subsequent observation of SBR-like symptoms in **counties** where soybean rust has already been confirmed.	Send sample to the diagnostic lab/authority designated by the State (Identification may be based on morphology, or both morphology and PCR.)	N/A. DO NOT SEND TO PPQ	Diagnostic authority enters record into database [PDIS, SPDN, NAPIS, Industry, or APHIS]

APPENDIX C:

TIMELINE

2004

September

- Soybean rust believed to have entered United States, possibly as a result of Hurricane Ivan or other tropical storms.

November

- Soybean Rust first identified in United States

December

- Working group begins to draft a Coordinated Framework for Soybean Rust.

2005

February

- Roll out of Coordinated Framework Document to stakeholders in Indianapolis.
- PDA program for industry protocol completed. First test of PDA program
- Soybean Rust Monitoring and Prediction System Public web site up and available and linked to USDA web site.

- National, regional, and state coordinators identified.
- Preseason climatological assessment of three scenarios using the Soybean Rust Aerobiology Prediction System available.

March

- USDA Soybean Rust Web Portal online.
- Refinement of monitoring plan at meeting of soybean researchers in Scottsdale, Arizona.
- PDA program for industry protocol released. Testing and release of program for mobile and sentinel plots protocols
- Soybean Rust Monitoring and Prediction Web Site active for data entry and PDA access. Interactive demonstration by Joe Russo in Riverdale (March 1).
- File transfer protocol available for users of industry protocol.
- State coordinators supply web links for state based information.
- Soybean Rust Aerobiology and Prediction system goes on-line with near real time and forecast data.
- Observations from NPDN available in map form and on-line.
- User evaluation of web site.
- NC 504 Guidelines fungicide Manual (pdf file format) linked to USDA web site.
- Pre-season interpretation guide written.

April

- SRMP web site tutorial available.
- Soybean Rust Monitoring and Prediction Web Site active for Research users. Observations from all collection protocols available in map form and on-line
- File transfer protocol available users of mobile and sentinel plots protocols.
- User evaluation of web site.
- Data transfer protocols available for monitoring data access by researchers.

May

- User evaluation of web site.
- Widespread planting and emergence of soybean in southern states.

June

- Widespread planting and emergence of soybean in northern states.

October onwards

- APS symposium on soybean rust to discuss lessons learned.

APPENDIX D:

NPDN Diagnostic Laboratories*			
States	**Diagnostician**	**Affiliation**	**E-mail**
Alabama	**Jackie Mullen**	Department of Entomology & Plant Pathology	mullejm@auburn.edu
Arkansas	**Stephen Vann**	Plant Disease Clinic	svann@uaex.edu
Colorado	**Tamla Blunt**	Colorado State University	tamblunt@lamar.colostate.edu
Delaware	**Bob Mulrooney**	Dept. of Plant and Soil Sciences	bobmul@udel.edu
Florida	**Richard Cullen**	University of Florida	recullen@ifas.ufl.edu
	Tim Schubert	FL Department of Agriculture	
	Phill Harmon	University of Florida	
Georgia	**Jan Fowler**		
	Jason Brock	University of Georgia	jbrock@arches.uga.edu
Idaho	**Krishna Mohan**		
	Elizabeth Vavricka	Idaho Department of Agriculture	
Illinois	**Nancy Pataky**	University of Illinois	npataky@uiuc.edu
Indiana	**Gail Ruhl**	Purdue University	ruhlg@purdue.edu
	Karen Rane	Purdue University	rane@purdue.edu
Iowa	**Paula Flynn**		
Kansas	**Judith O'mara**	Kansas State University	jomara@ksu.edu

	Joy Pierzynski	Kansas State University	
Kentucky	**Julie Beale**		jbeale@uky.edu
	Paul Bachi		pbachi@uky.edu
Louisiana	**Clayton Hollier**	Department of Plant Pathology	chollier@agctr.lsu.edu
Maryland	**Ethel Dutky**	University of Maryland	edutky@umd.edu
	John Bowers	Maryland Department of Agriculture	bowersjh@mda.state.md.us
	Rick Anaker	Maryland Department of Agriculture	
Michigan	**Jan Byrne**	Department of Plant Pathology	byrnejm@msu.edu
	Richard Kaitany	Michigan Department of Agriculture	kaitanyr@michigan.gov
Minnesota	**Sandee Gould**	University of Minnesota	gould001@umn.edu
Mississippi	**Clarissa Balbalian**	Mississippi Cooperative Extension Service	cbalbali@ext.msstate.edu
Missouri	**Simeon Wright**		
Nebraska	**Jennifer Chaky**		jchaky2@unl.edu
New Jersey	**Rich Buckley**	Rutgers University	clinic@aesop.rutgers.edu
	Carl Shultz	New Jersey Department of Agriculture	
New York	**Karen Snover-Clift**	Cornell University	kls13@cornell.edu
North Carolina	**Tom Creswell**		tom_creswell@ncsu.edu

North Dakota	**Kasia Kinzer**		
Ohio	**Nancy Taylor**	Ohio State University	taylor.8@osu.edu
Oklahoma	**Brian Olson**		olsonb@okstate.edu
Oregon	**Melodie Putnam**		
	Shawn Meng	Oregan Department of Agriculture	
Pennsylvania	**John Peplinski**	Penn State University	jdp3@psu.edu
	Seong Hwan Kim	Pennsylvania Department of Agriculture	
Puerto Rico	**Alejandro Segarra**		
South Carolina	**Meg Williamson**		
South Dakota	**Marty Draper**	South Dakota State University	Martin.Draper@sdstate.edu
Tennessee	**Tom Stebbins**		
	Alan Windham	University of Tennessee	awindha1@utk.edu
	Kirk Lemore	University of Tennessee	klemour@utk.edu
Texas	**Karl Steddom**	Texas A&M	
	Larry Barnes	Texas A&M	lwbarnes@ag.tamu.edu / l-barnes@tamu.edu
Virginia	**Mary Ann Hansen**		maryannh@vt.edu

Washington	**Jenny Glass**		
West Virginia	**John Baniecki**		
Wisconsin	**Brian Hudelson**	University of Wisconsin	bdh@plantpath.wisc.edu
*** Individuals authorized to conduct diagnostics are provided with a password, in advance, for entering both "Survey and Diagnostics" data into the "APHIS" database**			